

Phase II Project Summary

Firm: Michigan Aerospace Corporation

Contract Number: NNX11CB60C

Project Title: Molecular Air Data Clear Air Turbulence Sensor: MADCAT Phase II

Identification and Significance of Innovation: (Limit 200 words or 2,000 characters whichever is less)

Clear air turbulence (CAT), often referred to as "air pockets," is attributed to Kelvin-Helmholtz instabilities at altitudes usually above 18,000ft, often without visual cues, making it difficult to avoid. The vortices produced when atmospheric waves "break" can have diameters of 900-1200ft and tangential velocities of 70-85 ft/sec. CAT is dangerous to aircraft, recently demonstrated by United flight 967 from Washington-Dulles to Los Angeles on July 21, 2010, which encountered severe turbulence and landed in Denver with over 30 injured passengers, 21 requiring a hospital visit. MADCAT will be capable of providing not only a look-ahead capability to predict clear air turbulence but also a full air data solution (airspeed, angle of attack, angle of sideslip, pressure and temperature) and potentially detection of volcanic ash and icing conditions if combined in a sensor suite with other components currently being developed at Michigan Aerospace. The technology would provide an unprecedented flight safety and ride comfort capability.

Technical Objectives and Work Plan: (Limit 200 words or 2,000 characters whichever is less)

The goal of this Phase II effort was to demonstrate the Direct Detection, DMD-based LIDAR systems capability to measure atmospheric parameters that are critical to identifying clear air turbulence such as wind speed/direction and density. Objectives were:

Objective 1: Finalize the design specifications.

Objective 2: Design, fabricate and test an engineering model to demonstrate the instrument's capabilities.

Objective 3: Recommend a final design for fabrication and test on a flight platform.

While a flight instrument is beyond the scope of this Phase II, a full ground instrument with hemispheric scanning was assembled in collaboration with NIST. This instrument allowed for both a demonstration instrument and a sand box for the development of the flight version of MADCAT.

The Work Plan included the following tasks:

Task 1: Finalization of Lidar Specifications

Task 2: Engineering Model Design, Fabrication and Assembly, and Algorithm Development

Task 3: Test Design

Task 4: Technology demonstration Tests

Task 5: Air Platform Instrument Design and Recommendations

Technical Accomplishments: (Limit 200 words or 2,000 characters whichever is less)

Michigan Aerospace was able to successfully collect velocity measurements using a never-before demonstrated adaptive interferometer measurement technique called the Programmable Edge Technique (PET), which makes use of a Digital Micro-mirror Device (DMD) in conjunction with a Fabry-Perot interferometer and two photo-multiplier tubes (PMT). The promise of this technology over the conventional charged-coupled device (CCD) method is the ability to provide much smaller range bins along the line of sight. With further algorithm development density can be calculated. More testing is necessary to fully test this new technique and demonstrate its advantage over the CCD-based approach whose results can be seen in Section 2.6. Further testing will take place over the next few weeks and these results will be provided to NASA at no cost to the program.

NASA Application(s): (Limit 100 words or 1,000 characters whichever is less)

The technology developed under this effort will open new possibilities for additional experimental research and characterization of CAT. MADCAT will allow NASA aircraft the benefit of having a clear-air turbulence warning system and an optical air data system in one package, suitable for general use by NASA aircraft as well as for flight research concerning clear-air turbulence and scientific studies of atmospheric processes. Ground-based research uses include measuring wind speed and direction along with air temperature and density while also detecting and characterizing turbulence; this could find use in large wind tunnels and near airports.

Non-NASA Commercial Application(s): (Limit 200 words or 2,000 characters whichever is less)

Clear-air turbulence represents a significant hazard and passenger-comfort issue, and the proposed MADCAT system will be very useful for commercial aircraft not only as a turbulence-warning solution, but also as an air data system that is more reliable than current speed-sensing technologies. Information on winds near aircraft, if downlinked and compiled, will be of significant value to weather forecasters, especially from aircraft flying over areas (oceans, etc.) where balloon radiosonde releases and other wind measurements are sparse or non-existent; the National Weather Service lists the lack of more comprehensive wind-profile data as a major unmet data need for accurate, longer-range forecasts. Turbulence detection with wind speed and direction data will find ground-based uses for wind farms (to detect approaching turbulence, gusts and direction changes, allowing corrective action) and for the military (in artillery and other munitions delivery and in the airdrop of supplies).

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